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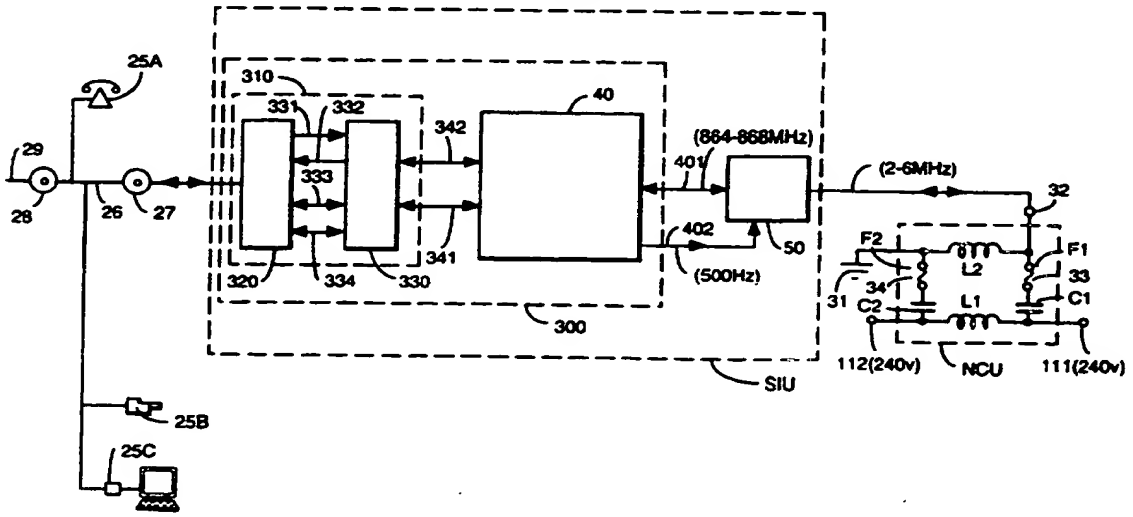
(54) A telecommunications method and system and a subscriber's interface unit of the system

(57) Telecommunications signals are carried on a cable 111 which carries mains electricity to a consumer's premises. A network conditioning unit NCU and a subscriber's interface unit SIU are provided between the mains cable 111 and conventional subscriber's terminal equipment (25A, 25B, 25C) adapted for full duplex communication with a local telephone exchange. The subscriber's interface unit SIU converts telecommunications signals between this duplex form (typically analogue at audio frequencies) and time division duplex (TDD) form at a carrier frequency in the range 1MHz to 20MHz for coupling to the mains cable 111. In the example, TDD interface means 40 provides cordless telephony digital standard formatting/deformatting and modulating/demodulating at a carrier in the band 864MHz to 868MHz, and a frequency converter 50 converts between this band and, typically, 2MHz to 6MHz.

Fig.3.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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A TELECOMMUNICATIONS METHOD AND SYSTEM, AND A SUBSCRIBER'S INTERFACE UNIT OF THE SYSTEM

This invention relates to a telecommunications method and system in which telecommunications signals are carried on a cable which carries mains electricity supply to a consumer's premises.

From published patent application GB-A-2,272,350 (Norweb) there is known a telecommunications system, in which system; a telecommunications subscribers' apparatus is located at each of a plurality of low voltage a.c. mains electricity supply consumer's premises; a telecommunications base station for communicating with said subscriber's apparatus at said plurality of consumer's premises is located in the electricity supply distribution network; and a network conditioning unit is located at each said consumer's premises for coupling telecommunications signals at a carrier frequency of greater than approximately 1MHz between the subscriber's apparatus and a cable carrying the mains supply to the premises, whereby the mains supply cable carries said telecommunications signals, and for providing electrical isolation between the subscriber's apparatus and the voltage of the mains supply.

The essential feature of the invention of GB-A-2,272,350 is the network conditioning unit which is disclosed in one example as being located at a consumer's premises as specified above and in other examples as enabling speech or data to be communicated via transceiver/modems on an 415V section of an electrical power distribution network. It is suggested that for a 415V network the carrier frequency may preferably be between 1-20 MHz; that voice and data signals may be transmitted over any or all of the sections of the power network by suitable detection, amplification and/or regeneration and reintroduction as and

when necessary; that preferably full duplex facilities are provided; that transmission techniques including both frequency and time division multiplexing may be used; and that the spread spectrum method offers inherent security and good interference rejection characteristics using a large bandwidth. A detailed description is given of the electrical circuit and physical make-up of a network conditioning unit located at the premises of a user of 50Hz, 240V single phase or 415V three phase electricity supply including a port to which a user's communication equipment would be connected.

The disclosure of GB-A-2,272,350 (Norweb) leaves problems to be solved in the case where telecommunications subscriber's apparatus is located at each of a plurality of low voltage (240V/415V) a.c. mains electricity supply consumer's premises. Using the spread spectrum large bandwidth as suggested by Norweb it would be difficult to provide a telecommunications service from a single base station to a plurality of subscribers with carrier frequencies between 1-10MHz as suggested by Norweb. Also the user's communication equipment, which is not considered by Norweb in any detail, must provide subscriber's apparatus which is compatible in use with the chosen transmission method while being convenient and reasonably affordable for the subscriber.

An object of the present invention is to provide a solution to these problems.

According to one aspect of the present invention there is provided a method of conveying signals between subscriber's apparatus and a base station in a telecommunications system, in which system; said subscriber's apparatus is located at each of a plurality of low voltage a.c. mains electricity supply consumer's premises; said base station for communicating with said subscriber's apparatus at said plurality of consumer's premises is located in the electricity supply distribution network; and a network conditioning unit is located at each said consumer's premises for coupling telecommunications signals at a carrier frequency of greater than approximately 1MHz between the

subscriber's apparatus and a cable carrying the mains supply to the premises, whereby the mains supply cable carries said telecommunications signals, and for providing electrical isolation between the subscriber's apparatus and the voltage of the mains supply; wherein telecommunications signals are transmitted in full duplex form between that terminal equipment and a public switched telephone network local exchange.

Preferably, in each said subscriber's apparatus signals are converted in a subscriber's interface unit between said full duplex form and time division duplex form at a carrier frequency in the range 1MHz to 20MHz for coupling to said mains supply cable by said network conditioning unit.

According to another aspect of the present invention there is also provided a a telecommunications system having a network conditioning unit located at each said consumer's premises for coupling telecommunications signals at a carrier frequency of greater than approximately 1MHz between the subscriber's apparatus and a cable carrying the mains supply to the premises, whereby the mains supply cable carries said telecommunications signals, and for providing electrical isolation between the subscriber's apparatus and the voltage of the mains supply, wherein each subscriber's apparatus includes a subscriber's terminal equipment adapted for transmission of telecommunications signals in full duplex form between that terminal equipment and a public switched telephone network local exchange; and a subscriber's interface unit for conversion of telecommunications signals between said full duplex form and time division duplex form at a carrier frequency in the range 1MHz to 20MHz for coupling to said mains supply cable by said network conditioning unit.

In the method and system according to the invention, use of time division duplex transmission technique on the mains supply cable saves on bandwidth required for a plurality of subscribers, and use of respectively provision of the interface unit enables each subscriber to

use conventional public switched telephone network terminal equipment such as a voice telephone, facsimile machine or computer modem.

Preferably, in the method and system according to the invention said base station is located at a local substation supplying said low voltage mains supply to said plurality of consumer's premises, and said telecommunications signals are communicated between said base station and at least most of said consumer's premises without amplification or regeneration. We have found by experiment that using carrier frequencies up to 20MHz signal amplification or regeneration is not necessary for the usual distance of up to approximately 300m between a local substation supplying low voltage mains electricity and the consumer's premises.

According to the present invention there is further provided a subscriber's interface unit of a telecommunications system having the characterising features as defined above, optionally with the further features as specified in the penultimate paragraph above, said interface unit being characterised by including; first conversion means for conversion of telecommunications signals between said full duplex form and a time division duplex form at a carrier frequency above 20MHz; and second conversion means for conversion of telecommunications signals between said time division duplex form at said carrier frequency above 20MHz and the same time division duplex form at said carrier frequency in the range 1 MHz to 20MHz.

In the method according to the invention there may be, in said interface unit, conversion of telecommunications signals between said full duplex form and a time division duplex form at a carrier frequency above 20MHz; and conversion of telecommunications signals between said time division duplex form at said carrier frequency above 20MHz and the same time division duplex form at said carrier frequency in the range 1MHz to 20MHz.

This method of the penultimate paragraph there may be conversion, or correspondingly in the interface unit of the preceding paragraph there

may be adaptation of the first conversion means for conversion, of telecommunications signals between said full duplex form as analogue signals and said time division duplex form at said carrier frequency above 20MHz. Thus conventional telephone subscriber's terminal equipment may be used transmitting and receiving voice or data information at audio frequencies. It is envisaged that conversion in the method, or correspondingly adaptation of the first conversion means, could otherwise be of said full duplex signals as digital signals such that more recent integrated systems digital network telephone subscriber's terminal equipment could be used transmitting and receiving voice and data information at a line rate of 192kbit/s.

In accordance with a further aspect of the invention, said conversion of telecommunications signals between said full duplex form and said time division duplex form at a carrier frequency above 20MHz preferably includes; conversation between telecommunications signals in said duplex form and comprising user information and signalling information on a single path and telecommunications signals in digital form and comprising said user information and said signalling information on separate paths; and conversation between telecommunications signals in said digital form with user information and signalling information on separate paths and telecommunications signals on a single path in said time division duplex form having a predetermined digital format at said carrier frequency above 20MHz.

The conversion between telecommunications signals in said digital form with user information and signalling information on separate paths and theelcommunications signals on a single path in said time division duplex form having said predetermined digital format at said carrier frequency above 20MHz specified in the preceding paragraph may include; converting said telecommunications signals in said digital form with user information and signalling information on separate paths into digital signals in said predetermined time division duplex format before modulation onto said carrier frequency above 20MHz. Converting digital signals in said predetermined time division duplex format after demodulation from said carrier frequency above 20MHz into said

telecommunications signals in said digital form with user information and signalling information on separate paths, and generating a time division duplex burst timing signal; modulating said digital signals in said predetermined time division duplex format onto said carrier frequency above 20MHz in a transmission path under control of said burst timing signal; conveying telecommunications signals from said transmission path to said single path in said predetermined time division duplex format under control of said burst timing signal; conveying telecommuncations signals from said single path in said predetermined time division duplex format to a reception path under control of said burst timing signal; and demodulating digital signals from said carrier frequency above 20MHz in said predetermined time division duplex format in said reception path under control of said burst timing signal.

In the subscriber's interface unit according to the invention, said first conversion means preferably includes; signal separation interface means for conversion between telecommunications signals in said duplex form and comprising user information and signalling information on a single path and telecommunications signals in digital form and comprising said user information and said signalling information on separate paths; and time division duplex interface means for conversion between telecommunications signals in said digital form with user information and signalling information on separate paths and telecommunications signals on a single path in said time division duplex form having a predetermined digital format at said carrier frequency above 20MHz.

Such time division duplex interface means may include; formatting/deformatting means for converting said telecommunications signals in said digital form with user information and signalling information on separate paths into digital signals in said predetermined time division duplex format before modulation onto said carrier frequency above 20MHz, for converting digital signals in said predetermined time division duplex format after demodulation from said carrier frequency above 20MHz into said telecommunications signals in said digital form with user information and signalling information on

separate paths, and for generating a time division duplex burst timing signal; a transmission path having means controlled by said burst timing signal for modulating digital signals provided by said formatting/deformatting means in said predetermined time division duplex format onto said carrier frequency above 20MHz; a reception path having means controlled by said burst timing signal for demodulating digital signals from said carrier frequency above 20MHz and providing demodulated digital signals to said formatting/deformatting means in said predetermined time division duplex format; and a switch controlled by said burst timing signal for conveying telecommunications signals from said modulating transmission path to said single path in said predetermined time division duplex format and for conveying telecommunications signals from said single path in said predetermined time division duplex format to said demodulating reception path.

In the method or in the subscriber's interface unit as specified in any of the four preceding paragraphs, said predetermined time division duplex format and said carrier frequency above 20MHz are preferably in accordance with the digital cordless telephony CT2 standard. Advantages of using the CT2 standard are as follows. Existing radio handset circuitry can be comparatively easily and economically adapted and used to provide the time division duplex interface means as specified in the preceding paragraph. The CT2 4MHz bandwidth having 40 channels of 100KHz, on carrier frequencies between 864MHz and 868MHz, conveniently occupies only a small portion of the bandwidth available on the electricity supply cable when converted by the above specified second conversion means to a carrier frequency for each channel in the range 1MHz to 20MHz. For example, 40 channels in the range 2MHz to 6MHz will probably provide sufficient traffic capacity for the number of subscribers connected to a single telecommunications base station at a local electricity supply substation; and if additional capacity is required another 4MHz bandwidth can also be used, for example another 40 channels in the range 8MHz to 12MHz. It is envisaged that said predetermined time division duplex format and said carrier frequency above 20MHz could alternatively be in accordance with the digital cordless telephony DECT standard in which 10 carrier

frequencies are provided separated by 1728KHz between 1881.792MHz and 1897.344MHz, .i.e. occupying a bandwidth of 15.552MHz.

In the subscriber's interface unit according to the invention, said second conversion means preferably includes; a frequency converter including one mixing means and one local oscillator means which serve for frequency down conversion and for frequency up conversion in alternate time division duplex burst periods; one amplifier means having an amplifier input and an amplifier output; and switching means responsive to a or respectively the time division duplex burst timing signal generated within and derived from said first conversion means, such that for frequency down conversion by said frequency converter the amplifier input is coupled to said mixing means and the amplifier output is coupled to said network conditioning unit, and such that for frequency up conversion by said frequency converter the amplifier input is coupled to said network conditioning unit and the amplifier output is coupled to said mixing means.

The switching means may comprise a two input combiner having its output connected to the amplifier input, a two output splitter having its input connected to the amplifier output, and two switches controlled by said time division duplex burst timing signal, such that for frequency down conversion the first switch couples the mixing means to one input of the combiner and the second switch couples one output of the splitter to the network conditioning unit, and such that for frequency up conversion the second switch couples the network conditioning unit to the other input of the combiner and the first switch couples the other output of the splitter to the mixing means.

Frequency conversion provided by the second conversion means of the subscriber's interface unit will involve inherent loss, principally loss in ensuring a suitably low power level for operation of the mixing means in the frequency converter and loss in the mixing means itself. Since the mains electricity supply cable will have a high loss for the telecommunications signals along its length between the consumer's premises and the local substation, it is desirable to provide amplification

in the second conversion means to overcome the just described loss inherent in frequency conversion. Using one mixing means and one local oscillator means for frequency down conversion in transmission from the subscriber and for frequency up conversion in reception by the subscriber, together with one amplifier means operated bi-directionally, is particularly advantageous for component costs, power consumption and stability compared with using a separate frequency converter and amplifier for transmission and reception. There is also an advantage in the time division duplex burst timing signal used for controlling this bi-directional operation being substantially cost-free in being already generated in the first conversion means which provides conversion of the telecommunications signals between full duplex form and time division duplex form.

An exemplary embodiment of a telecommunications method and system in accordance with the present invention, and in particular of the subscriber's interface unit of this system, will now be described in detail with reference to the accompanying drawings, in which:

Figure 1 shows a substation and low voltage cables for supplying electricity to a plurality of consumer's premises, with a telecommunications base station located in the substation for communication with the consumer's premises via the electricity cables.

Figure 2 shows one of the consumer's premises of Figure 1 with a subscriber's interface unit which couples telephone subscriber's terminal equipment to the electricity supply cable via a network conditioning unit.

Figure 3 shows circuit details of the network conditioning unit of Figure 2, and also shows a block schematic circuit of the subscriber's interface unit of Figure 2 comprising first conversion means connected to the subscriber's terminal equipment and second conversion means connected to the network conditioning unit.

Figure 4 shows schematic circuit details of time division duplex interface means which is part of the first conversion means of Figure 3, and

Figure 5 shows schematic circuit details of the second conversion means of Figure 3.

Referring now to Figure 1, a plurality of low voltage a.c. mains electricity supply consumer's premises 10 are shown connected by a distribution network of 415V three phase/240V single phase 50Hz mains supply cables 11 to a local substation SS in which the 415V is derived from an incoming 11KV cable 12 via a transformer 13. A telecommunications base station BS is located at the substation SS and telecommunications signals are carried on the mains supply cables 11 between the base station BS and subscriber's apparatus in at least some of the consumer's premises 10. The base station BS is connected between an injection point 14 on the 415V side of the transformer 13 and a transmission path 15 which is connected further into a telecommunications system.

Communication of telecommunications signals between the base station BS and a consumer's premises 10 is each time at a selected carrier frequency in the range 1MHz to 20MHz. We have found by experiment that using carrier frequencies up to 20MHz signal amplification or regeneration is not necessary for the usual distance of up to approximately 300m between a local substation SS supplying low voltage mains electricity and a consumer's premises 10. If it is necessary for longer distances between the substation SS and a consumer's premises 10, amplification or regeneration may be provided at a suitable point along that distance. We consider it to be most convenient and practical for the telecommunications base station BS to be located at the local substation SS as shown in Figure 1. However the base station BS could be located elsewhere in the electricity supply distribution network, for example it could be located at a 33kV to 11kV transformer station which distributes 11kV electricity supply to a number of local substations BS with amplification and regeneration being provided at each substation BS.

Referring now to Figure 2, a 240V single phase 50Hz a.c. mains electricity supply cable 11 is shown entering a consumer's premises 10, and this mains supply is connected via the usual fuse 21 to the usual meter box 22 which connects to power circuits 23 and lighting circuits 24

in the consumer's premises 10. A network conditioning unit NCU, which will be described in detail later with respect to Figure 3, is connected between the fuse 21 and the meter box 22. The network conditioning unit is primarily for coupling telecommunications signals at the selected frequency in the range 1MHz to 20MHz between telecommunications subscriber's apparatus in the consumer's premises 10 and the mains supply cable 11, and for providing electrical isolation between this subscriber's apparatus and the voltage of the mains supply.

The subscriber's apparatus in the consumer's premises includes conventional public switched telephone network terminal equipment such as a voice telephone 25A, facsimile machine 25B or computer modem 25C which is adapted for transmission of telecommunications signals in full duplex form between that terminal equipment and a public switched telephone network local exchange. Figure 2 shows a conventional telephone terminal point 28 connected to a conventional two-wire line 29 leading to such a local exchange. When used in the telecommunications system of this invention, the terminal equipment 25A and/or 25B, 25C is instead connected by the subscriber's telephone cable 26 to another, similar, telephone terminal point 27. The subscriber's apparatus in the consumer's premises also includes a subscriber's interface unit SIU, connected between the terminal point 27 and the network conditioning unit NCU. The subscriber's interface unit SIU is for conversion of telecommunications signals between the full duplex form and time division form at the carrier frequency in the range 1MHz to 20MHz for coupling to the mains supply cable 11 by the network conditioning unit NCU.

The network conditioning unit NCU will in practice be installed at each consumer's premises 10 connected by electricity supply cable 11 to a common injection point 14 leading to a telecommunications system base station BS (as shown in Figure 1), whether or not that particular consumer's premises also has a subscriber's interface unit SIU enabling subscriber's terminal equipment 25A, 25B, 25C to be connected in the telecommunications system of this invention. This is because the network conditioning unit NCU also serves for preventing noise sources

from the internal low voltage premises wiring 23, 24 at each premises 10 contaminating or corrupting the telecommunications signals being transmitted between any of the premises 10 and the injection point 14.

Referring now to Figure 3, exemplary circuit details are shown of the network conditioning unit NCU and a block schematic circuit is shown of the subscriber's interface unit SIU.

The exemplary circuit details of the network conditioning unit NCU are essentially as disclosed in Figure 3 and the accompanying description of GB-A-2,272,350 (Norweb). That description is summarised and adapted to the present Figure 3 as follows. A mains electricity input 111 from the fuse 21 (Figure 2) carries 50Hz single phase 240V electrical power at a maximum current of 100 amps to an output 112 to the meter box 22 (Figure 2). The unit is in a metal box which prevents radiation of communications signals to externally located appliances and provides a connection 31 to earth for a signal input/output port 32. A filter includes a first inductor L1 each end of which is provided with a connection to the signal port 32. A first connection 33 between the mains electricity input 111 and the signal port 32 consists of a capacitor C1 and a fuse F1 arranged to blow in the event of failure or fault in the capacitor C1. A second connection 34 includes a second capacitor C2 providing attenuation of the communication signals by shorting to earth 31 and a second fuse F2 provided to blow in the event of a fault in the capacitor C2. A second inductor L2 provides a path to earth 31 in the event of failure of the coupling capacitor C1 for the 50Hz mains electricity power frequency thereby blowing the fuse F1. The inductor L2 has no effect on the communication signals present at the signal input/output port 32. The inductors L1 and L2 are high impedance elements over the required telecommunications frequency spectrum of 1MHz to 20MHz. The capacitors C1 and C2 are low impedance elements over the required telecommunications frequency spectrum of 1MHz to 20MHz and high impedance isolating elements at the 50Hz frequency of the mains electricity supply.

The subscriber's interface unit SIU consists of first conversion means 300 for conversion of telecommunications signals between full duplex form at the telephone terminal point 27 and time division duplex form at a carrier frequency above 20MHz, and second conversion means 50 for conversion of telecommunications signals between this time division duplex form at this carrier frequency above 20MHz and the same time division duplex form at the network conditioning unit input/output port 32 but at the carrier frequency in the range 1MHz to 20MHz. All the circuits of the subscriber's interface unit SIU may be powered by a suitable d.c. voltage derived from the consumer's mains supply.

The first conversion means 300 includes signal separation interface means 310 for conversion between telecommunications signals in duplex form at the terminal 27 and comprising user information and signalling information on a single path provided by the subscriber's telephone cable 26 and telecommunications signals in digital form and comprising the user information 341 and the signalling information 342 on separate paths as shown in Figure 3. The first conversion means 300 also includes time division duplex interface means 40 for conversion between telecommunications signals in the digital form with user information 341 and signalling information 342 on separate paths and telecommunications signals on a single path 401 in the time division duplex form having a predetermined digital format at the carrier frequency above 20MHz.

The signal separation interface means 310 will now be described in detail with reference to Figure 3. This will be followed by a description of the detail of the time division duplex interface means 40 with reference to Figure 4 and then a description of the detail of the second conversion means 50 with reference to Figure 5.

The signal separation interface means 310 consists of a line card unit 320 and a processing unit 330. The full duplex signals at the telephone point 27 are analogue signals at audio frequencies on a single path. The line card unit 320 is a commercially available circuit, similar in function to a conventional local exchange line circuit, which provides

conversion between these analogue signals on a single path and the conventional components of these analogue signals on separate paths. These components are the three components of signalling information as the outgoing off-hook signal on path 331, the incoming ringing signal on path 332, and the outgoing multifrequency address signals on path 333, and also the two-way user information signals (voice or data) on path 334. The processing unit 330 includes analogue to digital conversion, digital to analogue conversion and a micro-processor function which together effect conversion between the user information (voice or data) in analogue form on path 334 and that user information in digital form on path 341, and also effect conversion between the off-hook, ringing and address signalling information in analogue form on paths 331, 332 and 333 and that signalling information in digital form combined on path 342 separate from path 341.

It is envisaged that an alternative implementation of the signal separation interface means 310 could be provided for the case where the voice telephone 25A, facsimile machine 25B or computer modem 25C are provided with ISDN (integrated systems digital network) termination equipment for full duplex transmission and reception of user and signalling information in digital form, or where the subscriber's terminal equipment such as a voice telephone is integrally adapted for digital operation. In this case the full duplex signals at the telephone point 27 will be digital user and signalling information signals on a single path and the signal separation interface means 310 will provide conversion between these digital signals at the telephone point 27 and the user information 341 and signalling information 342 in digital form on separate paths.

Referring now to Figure 4, the time division duplex interface means 40 will be described in detail.

Formatting/deformatting means 41, which may be implemented essentially by a microprocessor, interfaces with the digital user information and digital signalling information paths 341, 342 and provides the following three functions. Firstly it converts the digital user

information 341 and the digital signalling information 342 into digital logical signals 411 in a predetermined time division duplex format before modulation onto a carrier frequency. Secondly it converts digital logical signals 412 in this predetermined time division duplex format after demodulation from this carrier frequency into the digital user information 341 and the digital signalling information 342. Thirdly it generates a time division duplex burst timing signal 402.

A transmission path 42 has a modulator 421, a frequency up converter 422 and a power amplifier 423 which are controlled by the burst timing signal 402 and provide the time division duplex formatted digital signals 411 modulated on to the carrier frequency above 20MHz in alternate time division duplex burst periods as telecommunications signals 424 to a switch 44.

The switch 44 is controlled by the burst timing signal 402 for conveying the telecommunications signals 424 from the modulating transmission path 42 via bandpass filter 45 to the single path 401. The switch 44 also conveys telecommunications signals 431 modulated on the same carrier frequency above 20MHz and in the same time division duplex format from the single path 401 and the bandpass filter 45 in alternate time division duplex burst periods to a reception path 43.

The reception path 43 has a low noise amplifier 432, a frequency down converter 433 and a demodulator 434 which are controlled by the burst timing signal 402 and provide the demodulated time division duplex formatted digital signals 412 to the formatting/deformatting means 41.

The above-mentioned predetermined time division duplex format and the above-mentioned carrier frequency above 20MHz in this exemplary embodiment of the invention are in accordance with the digital cordless telephony CT2 standard. The CT2 standard operates with a 4MHz bandwidth having 40 channels of 100KHz on carrier frequencies between 864MHz and 868MHz, and the time division duplex burst frequency is 500Hz. The modulator 421 and the demodulator 434 operate on a carrier frequency of 150MHz. Channel selection and

conversion to and from a particular carrier frequency in the 864MHz to 868MHz band is effected in the up converter 422 and in the down converter 433. The circuitry of the time division duplex interface means 40 may be custom designed, or it may be adapted from existing CT2 radio handset circuitry in which similar circuits to the formatting/deformatting means 41 interface with a line unit including a keypad, microphone and receiver of the radio handset and the single path 401 connects to an antenna of the radio handset. If such a radio handset line unit is made use of for the present invention then it will include the analogue to digital conversion and digital to analogue conversion functions which have been described above as functions of the processing unit 330 of the signal separation interface means and may still be considered as functions of this processing unit 330 for the purpose of this invention.

Referring now to Figure 5, the second conversion means 50 will be described in detail.

The second conversion means 50 includes a frequency converter 51, one amplifier means 52 and switching means 53.

The frequency converter 51 includes one mixing means 511 and one local oscillator means 512 which serve for frequency down conversion and for frequency up conversion in alternate time division duplex burst periods. An attenuator 513 is provided between the mixing means 511 and the path 401 to ensure a suitably low power level for operation of the mixing means 511 during frequency down conversion and a low pass filter 514 is provided on the other side of the mixing means. The frequency converter provides conversion between telecommunications signals in CT2 time division duplex format at a carrier frequency within the 4MHz band from 864MHz to 868MHz on the path 401 and these telecommunications signals in the same CT2 time division duplex format at the network conditioning unit input/output port 32 where they are at a carrier frequency also within a 4MHz band but within the range 1MHz to 20MHz, for example 2MHz to 6MHz.

The amplifier means 52 is a single amplifier chain having a low noise amplifier 521 and a high power amplifier 523 in series between an amplifier input 524 and an amplifier output 525.

The switching means 53 is responsive to the 500Hz time division duplex burst timing signal 402 generated within and derived from said first conversion means 300, such that for frequency down conversion by the frequency converter 51, the amplifier input 524 is coupled to the mixing means 511 and the amplifier output 525 is coupled to the network conditioning unit input/output port 32 via a low pass filter 54, and such that for frequency up conversion by the frequency converter 51 the amplifier input 524 is coupled to the network conditioning unit input/output port 32 via the filter 54 and the amplifier output 525 is coupled to the mixing means 511.

The switching means 53 is made up of a two input combiner 531 having its sum port connected to the amplifier input 524, a two output splitter 532 having its sum port connected to the amplifier output 525, and two switches 534, 535 controlled by the time division duplex burst timing signal 402, such that for frequency down conversion the first switch 534 couples the mixing means 511 to one input of the combiner 531 via the filter 514, and the second switch 535 couples one output of the splitter 532 to the network conditioning unit port 32 via the filter 54, and such that for frequency up conversion the second switch 535 couples the network conditioning unit port 32 to the other input of the combiner 531 via the filter 54, and the first switch 534 couples the other output of the splitter 532 to the mixing means 511 via the filter 514.

The loss provided by the attenuator 513 may be typically 10dB and by the mixing means 511 may be typically 7dB. The loss provided by the other components of the second conversion means 50 may typically amount to another 10dB. Since the mains electricity supply cable will have a high loss for the telecommunications signals along its length between the consumer's premises and the local substation, typically up to 40dB, it is desirable for the amplifiers 521, 523 to provide a gain which compensates for the losses in the second conversion means 50,

say 27dB gain in the case of this aggregate of typical losses just indicated.

Using one mixing means 511 and one local oscillator means 512 for frequency down conversion in transmission from the subscriber and for frequency up conversion in reception by the subscriber, together with one amplifier means 52 operated bi-directionally, is particularly advantageous for component costs, power consumption and stability compared with using a separate frequency converter and amplifier for transmission and reception. There is also an advantage in the time division duplex burst timing signal 402 used for controlling this bi-directional operation being substantially cost-free in being already generated in the first conversion means 300 which provides conversion of the telecommunications signals between full duplex form and time division duplex form.

CLAIMS

1. A method of conveying signals between subscriber's apparatus and a base station in a telecommunications system, in which system; said subscriber's apparatus is located at each of a plurality of low voltage a.c. mains electricity supply consumer's premises; said base station for communicating with said subscriber's apparatus at said plurality of consumer's premises is located in the electricity supply distribution network; and a network conditioning unit is located at each said consumer's premises for coupling telecommunications signals at a carrier frequency of greater than approximately 1MHz between the subscriber's apparatus and a cable carrying the mains supply to the premises, whereby the mains supply cable carries said telecommunications signals, and for providing electrical isolation between the subscriber's apparatus and the voltage of the mains supply; wherein telecommunications signals are transmitted in full duplex form between that terminal equipment and a public switched telephone network local exchange.

2. A method as claimed in claim 1 wherein, in each said subscriber's apparatus signals are converted in a subscriber's interface unit between said full duplex form and time division duplex form at a carrier frequency in the range 1MHz to 20MHz for coupling to said mains supply cable by said network conditioning unit.

3. A method as claimed in claims 1 or 2 wherein, with said base station being located at a local substation supplying said low voltage mains supply to said plurality of consumer's premises, said signals are communicated between said base station and at least most of said consumer's premises without amplification or regeneration.

3. A method as claimed in claims 1 to 3 wherein, in said interface unit;

there is conversion of signals between said full duplex form and a time division duplex form at a carrier frequency above 20MHz; and

there is conversion of signals between said time division duplex form at said carrier frequency above 20MHz and the same time division duplex form at said carrier frequency in the range 1MHz to 20MHz.

5. A method as claimed in claim 4, wherein signals are converted between said full duplex form as analogue signals and said time division duplex form at said carrier frequency above 20MHz.

6. A method as claimed in claim 4 or 5, wherein said conversion of signals between said full duplex form and said time division duplex form at a carrier frequency above 20MHz includes;

conversion between signals in said duplex form and comprising user information and signalling information on a single path and telecommunications signals in digital form and comprising said user information and said signalling information on separate paths; and

conversion between signals in said digital form with user information and signalling information on separate paths and signals on a single path in said time division duplex form having a predetermined digital format at said carrier frequency above 20MHz.

7. A method as claimed in claim 6 where said conversation between signals in said digital form with user information and signalling information on separate paths and telecommunications signals on a single path in said time division duplex form having said predetermined digital format at said carrier frequency above 20MHz includes;

converting said signals in said digital form with user information and signalling information on separate paths into digital signals in said predetermined time division duplex format before modulation onto said carrier frequency above 20MHz, converting digital signals in said predetermined time division duplex format after demodulation from said carrier frequency above 20MHz into said signals in said digital form with user information and signalling information on separate paths, and generating a time division duplex burst timing signal;

modulating said digital signals in said predetermined time division duplex format onto said carrier frequency above 20MHz in a transmission path under control of said burst timing signal;

conveying signals from said transmission path to said single path in said predetemined time division duplex format under control of said burst timing signal;

conveying telecommunications signals from said single path in said predetermined time division duplex format to a reception path under control of said burst timing signals; and

demodulating digital signals from said carrier frquency above 20MHz in said predetemined time division duplex format in said reception path under control of said burst timing signal.

8 A method as claimed in claim 6 or 7, wherein said predetermined time division duplex format and said carrier frequency above 20MHz are in accordance with the digital cordless telephony CT2 standard.

9. A telecommunications system, in which system;

telecommunications subscriber's apparatus is located at each of a plurality of low voltage a.c. mains electricity supply consumer's premises;

a telecommunications station for communicating with said subscriber's apparatus at said plurality of consumer's premises is located in the electricity supply distribution network; and

a network conditioning unit is located at each said consumer's premises for coupling signals at a carrier frequency of greater than approximately 1MHz between the subscriber's apparatus and a cable carrying the mains supply to the premises, whereby the mains supply cable carries said signals, and for providing electrical isolation between the subscriber's apparatus and the voltage of the mains supply;

wherein the subscriber's apparatus includes;

subscriber's terminal equipment adapted for transmission of telecommunications signals in full duplex form between that terminal equipment and a public switched telephone network local exchange; and

a subscriber's interface unit for conversion of telecommunications signals between said full duplex form and time division duplex form at a carrier frequency in the range 1MHz to 20MHz for coupling to said mains supply cable by said network conditioning unit.

10. A telecommunications system as claimed in claim 9, wherein said base station is located at a local substation supplying said low voltage mains supply to said plurality of consumer's premises, and wherein said telecommunications signals are communicated between said base station and at least most of said consumer's premises without amplification or regeneration.

11. The subscriber's interface unit of the telecommunications system as claimed in claim 8 or claim 9, said interface unit includes;

first conversion means for conversion of telecommunications signals between said full duplex form and a time division duplex form at a carrier frequency above 20MHz; and

second conversion means for conversion of telecommunications signals between said time division duplex form at said carrier frequency above 20MHz and the same time division duplex form at said carrier frequency in the range 1MHz to 20MHz.

12. A subscriber's interface unit as claimed in claim 11, wherein said first conversion means is adapted for conversion of telecommunications signals between said full duplex form as analogue signals and said time division duplex form at said carrier frequency above 20MHz.

13. A subscriber's interface unit as claimed in claim 11 or 12, wherein said first conversion means includes;

signal separation interface means for conversion between telecommunications signals in said duplex form and comprising user information and signalling information on a single path and telecommunications signals in digital form and comprising said user information and said signalling information on separate paths; and

time division duplex interface means for conversion between telecommunications signals in said digital form with user information and signalling information on separate paths and telecommunications signals on a single path in said time division duplex form having a predetermined digital format at said carrier frequency above 20MHz.

14. A subscriber's interface unit as claimed in claim 13, wherein said time division duplex interface means includes;

formatting/deformatting means for converting said telecommunications signals in said digital form with user information and signalling information on separate paths into digital signals in said predetermined time division duplex format before modulation onto said carrier frequency above 20MHz, for converting digital signals in said predetermined time division duplex format after demodulation from said carrier frequency above 20MHz into said telecommunications signals in said digital form with user information and signalling information on separate paths, and for generating a time division duplex burst timing signal;

a transmission path having means controlled by said burst timing signal for modulating digital signals provided by said formatting/deformatting means in said predetermined time division duplex format onto said carrier frequency above 20MHz;

a reception path having means controlled by said burst timing signal for demodulating digital signals from said carrier frequency above 20MHz and providing demodulated digital signals to said formatting/deformatting means in said predetermined time division duplex format; and

a switch controlled by said burst timing signal for conveying telecommunications signals from said modulating transmission path to said single path in said predetermined time division duplex format and for conveying telecommunications signals from said single path in said predetermined time division duplex format to said demodulating reception path.

15 A subscriber's interface unit as claimed in claim 13 or 14, wherein said predetermined time division duplex format and said carrier frequency above 20MHz are in accordance with the digital cordless telephony CT2 standard.

16 A subscriber's interface unit as claimed in any one of claims 11 to 15, wherein said second conversion means includes;

a frequency converter including one mixing means and one local oscillator means which serve for frequency down conversion and for frequency up conversion in alternate time division duplex burst periods;

one amplifier means having an amplifier input and an amplifier output; and

switching means responsive to a or respectively the time division duplex burst timing signal generated within and derived from said first conversion means, such that for frequency down conversion by said frequency converter the amplifier input is coupled to said mixing means and the amplifier output is coupled to said network conditioning unit, and such that for frequency up conversion by said frequency converter the amplifier input is coupled to said network conditioning unit and the amplifier output is coupled to said mixing means.

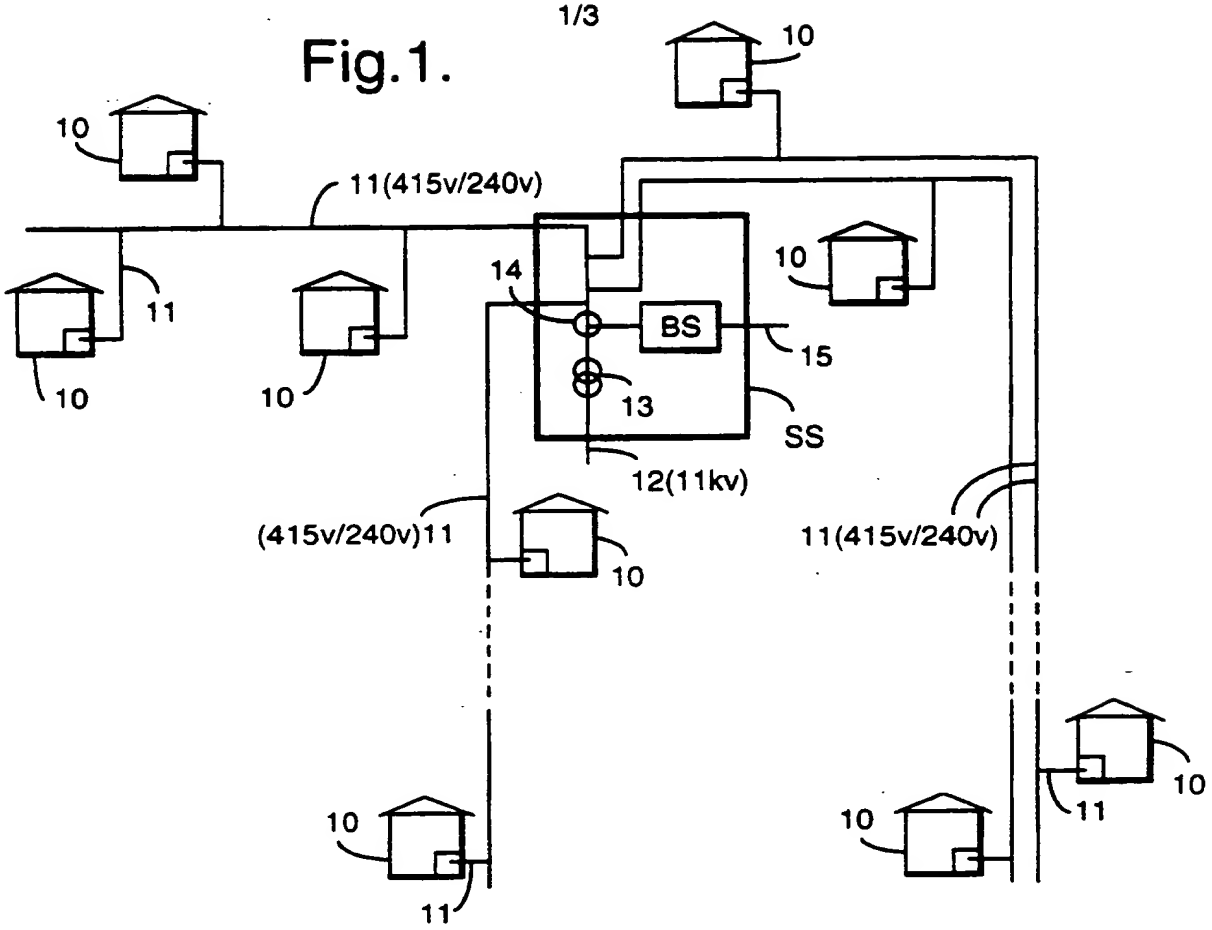
17. A subscriber's interface unit as claimed in claim 16, wherein said switching means comprises a two input combiner having its output connected to the amplifier input, a two output splitter having its input connected to the amplifier output, and two switches controlled by said time division duplex burst timing signal, such that for frequency down conversion the first switch couples the mixing means to one input of the combiner and the second switch couples one output of the splitter to the network conditioning unit, and such that for frequency up conversion the second switch couples the network conditioning unit to the other input of the combiner and the first switch couples the other output of the splitter to the mixing means.

18. A method of conveying telecommunications signals substantially as herein described with reference to the accompanying drawings.

19. A telecommunications system substantially as herein described with reference to the accompanying drawings

20. The subscriber's interface unit of the telecommunications system as claimed in claim 11 and substantially as herein described with reference to Figures 2 to 5 as shown in the accompanying drawings sheets.

Fig.1.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11
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14
BS
15
13
SS
12(11kv)
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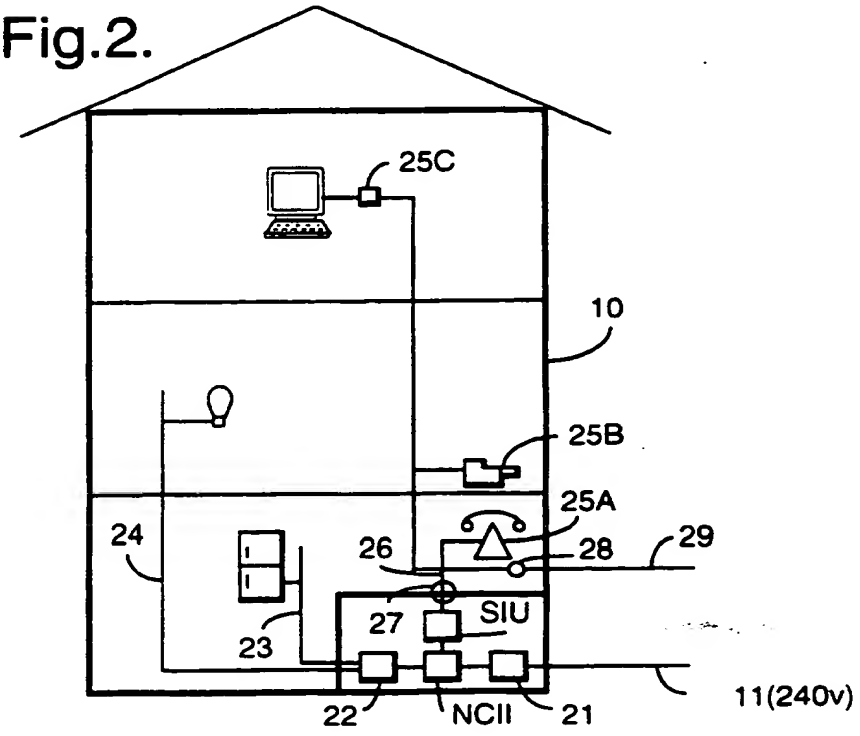
(415v/240v)11
10
11(415v/240v)
10
10
11
10
11

Fig.2.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25B
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29
27
SIU
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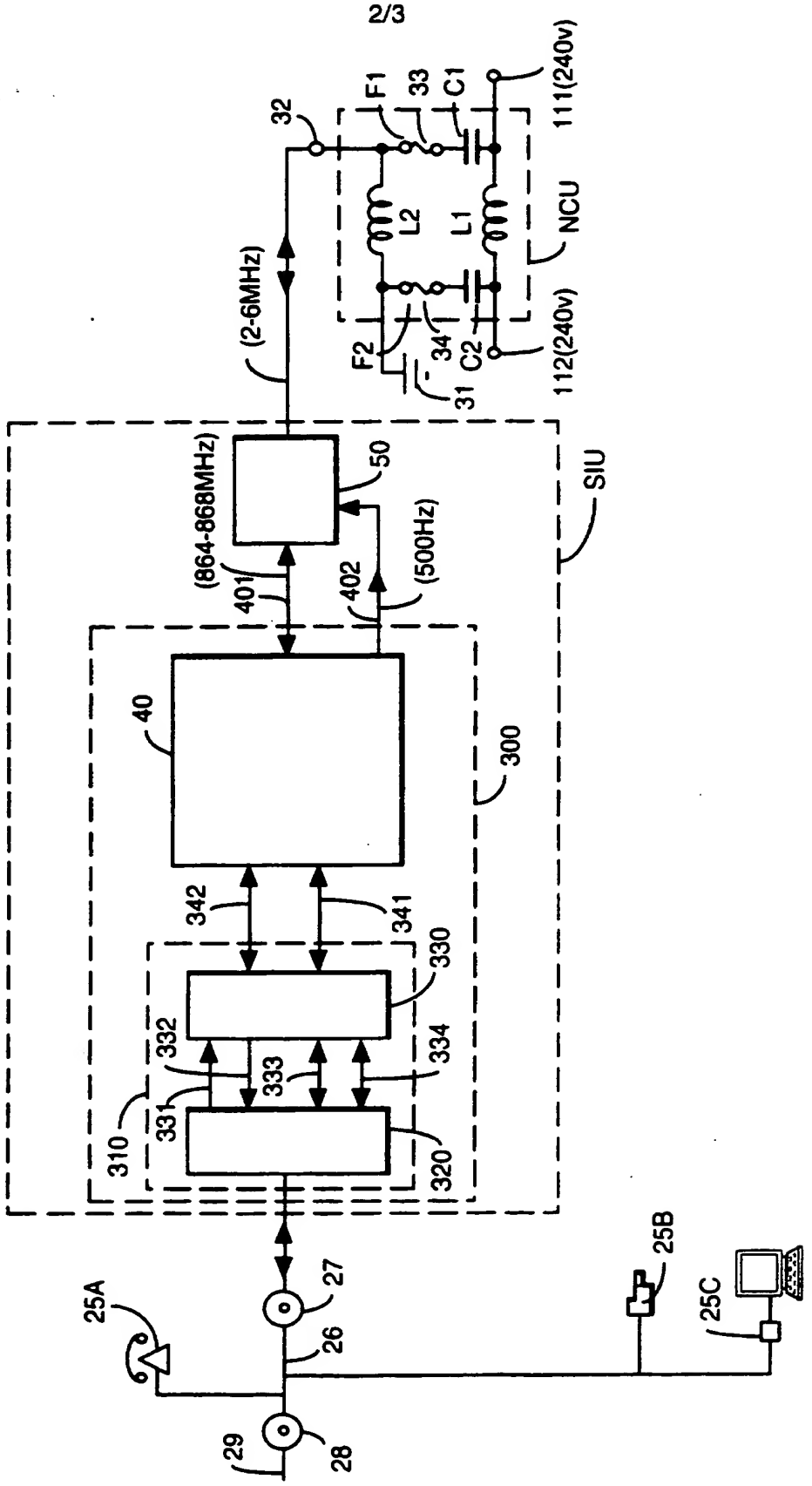
NCII
21
11(240v)

Fig.3.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33
F1
32
L2
L1
NCU
(2-6MHz)
F2
34
C2
31
112(240v)
SIU
50
(864-868MHz)
(500Hz)
401
402
40
300
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341
330
332
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333
331
310
320
27
25A
26
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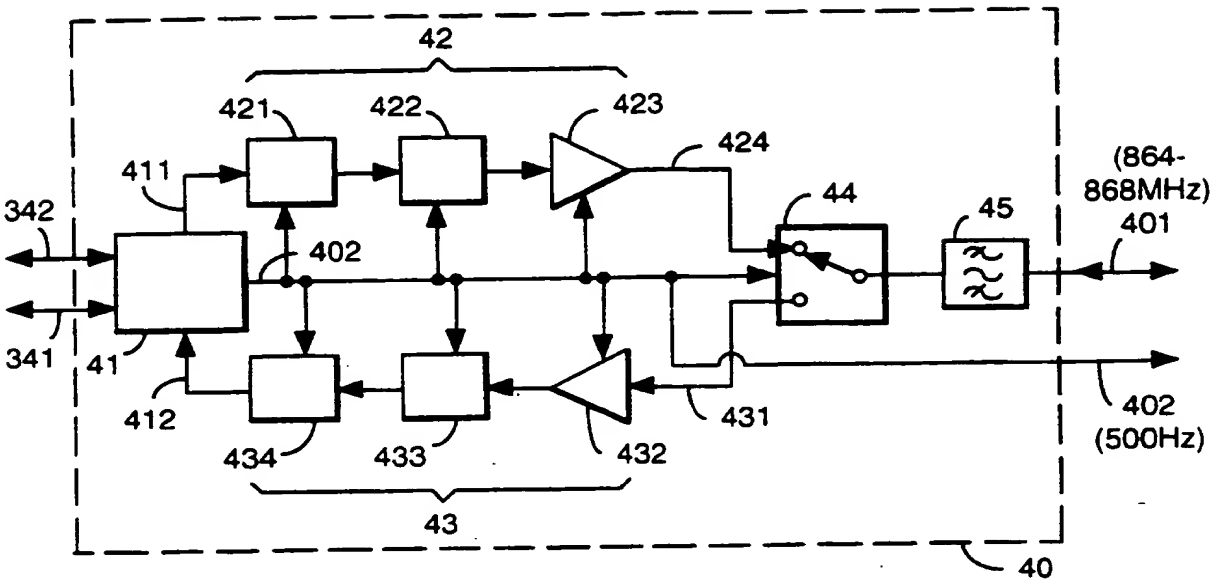
28
25B
25C

Fig.4.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401
412
434
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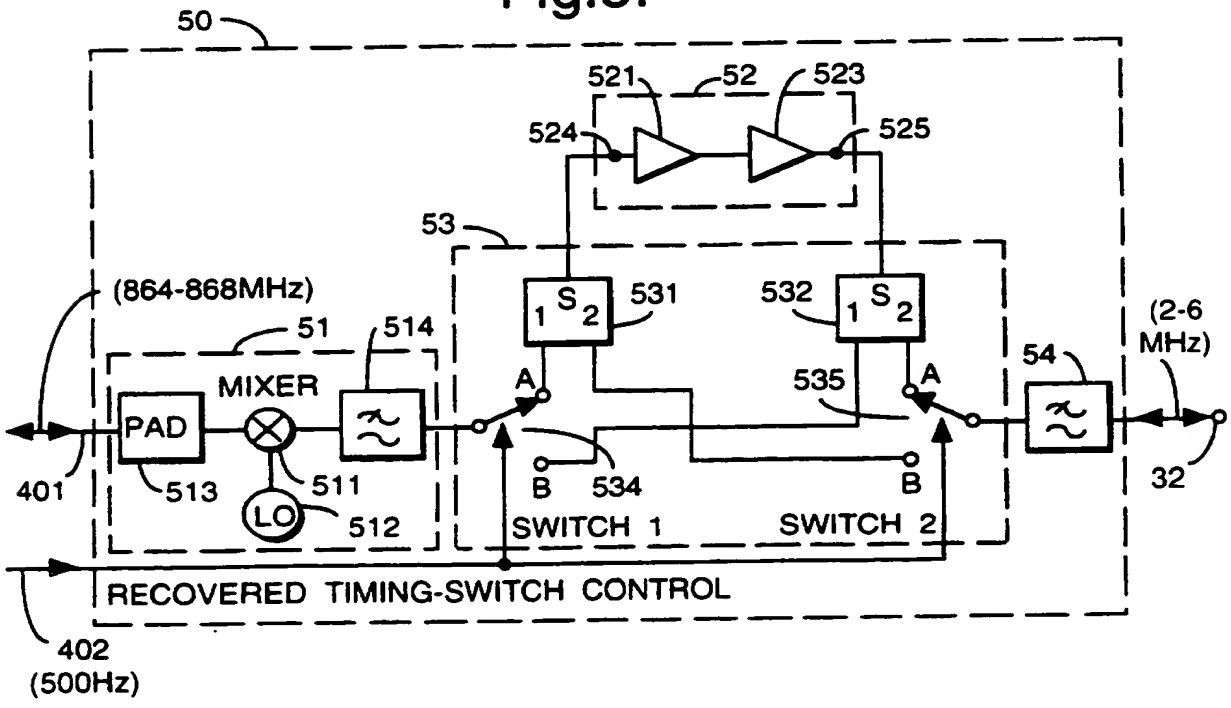
432
431
402
(500Hz)
43
40

Fig.5.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523
524
525
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(864-868MHz)
51
514
531
532
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2
MIXER
PAD
A
535
54
(2-6
MHz)
401
513
511
LO
512
B
534
B
32
SWITCH 1
SWITCH 2
RECOVERED TIMING-SWITCH CONTROL
402
(500Hz)

The Patent Office

26

Application No: GB 9610266.0
Claims searched: ALL

Examiner: Mr.SAT SATKURUNATH
Date of search: 13 August 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4R: RTC, RTSR, RTSU

Int Cl (Ed.6): H04B

Other: Online: WPI, JAPIO, INSPEC

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	WO 95/29537 A1 NORWEB - see especially claim 1 and lines 18-22 on page 8	1, 9

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.